E-94-016: Measuring Rare Radiative Decays of the Phi Meson

The study of the radiative decays of the heavier vector mesons, J/psi (charmonium: c-cbar) and upsilon (bottomonium: b-bbar), soon after their discovery, played an important role in understanding quarkonium spectroscopy. Interestingly enough, although the phi (strangeonium: s-sbar) was discovered earlier, much less is known about its radiative decays. One can enumerate seven energetically allowed decays phi -> X gamma, where X is a particle. Only two have been observed: phi -> pi0 gamma and phi -> eta gamma. Although phase space would favor the former, the branching ratio for the latter is greater by an order of magnitude, reflecting the s-sbar contribution to the quark content of the eta. Two of the energetically allowed decays, phi -> rho gamma and phi -> omega gamma are forbidden since they are C-violating. However, the experimental limits on the branching ratios (< few percent) for these modes are poorly determined. Another allowed decay involves a pseudoscalar: phi -> etaprime gamma, as yet unobserved, should provide information on the quark/gluon content of the etaprime. Radiative phi decays into the isoscalar f0(980) and isovector a0(980) could shed light on the substructure of these states. Originally assigned to the scalar nonet, there is mounting evidence that these are not q-qbar states. There is much theoretical speculation about what these states might be and possible interpretations include four-quark states and molecular states (K-Kbar). The measurement of the ratio: (phi -> a0 gamma)/(phi -> f0 gamma) should allow one to select among interpretations. The decays into these scalar states are also important since they provide information on phi -> Kshort Klong gamma, a potentially insidious background to CP-studies at an e+e- phi factory if the very low energy radiated photon goes undetected. A phi factory is predicated on a correlated source of neutral kaons since phi -> Kshort Klong.

Up to now, information on radiative decays comes from e+e- -> phi -> X gamma and one of the reasons for the paucity of data on these radiative decays is that the radiated photon is low in energy (Eg). Incidentally, the decays V -> P gamma and V -> S gamma (where V = vector, P = pseudoscalar and S = scalar) are E1 or M1 transitions and the resulting Eg**3 strongly damps the decay rate. At CEBAF, the photoproduction process will be used in this experiment to produce a fairly well collimated source of phi's, defined in energy and with a rate (30 phi's/sec) comparable to an e+e- luminosity of 10**31/cm**2/sec. This is comparable to what is currently available in colliders but the boost factor (as high as 12 for 6 GeV electrons) provides an important advantage. This experiment will use the tagged photon beam in Hall B. Photons in the range from 4 to 6 GeV will be incident on a Be target. A 624-element lead glass detector will be used to look at decays:

phi -> pi0 (or eta) gamma -> 3 gamma
phi ->omega gamma -> pi0 gamma gamma -> 4 gamma
phi -> f0 gamma -> pi0 pi0 gamma -> 5 gamma; and
phi -> a0 gamma -> pi0 eta gamma -> 5 gamma

Branching ratio sensitivities of 10**-4 to 10**-5 for the latter two modes can be achieved. These measurements will complement measurements in future ϕ factories, where the backgrounds and systematics are far different.

The experiment will be located in Hall B either in front of or in back of the CLAS detector and will likelt run sometime in 1997.